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Reproductive traits in primiparous sows in relation to feeding level

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Summary

To measure the effect of feeding level and induction of oestrus with 400 I.U. of Pregnant Mare Serum and 200 I.U. of Human Chorion Gonadotrophin, some reproductive and liveweight traits of 113 primiparous Dutch Landrace sows were analysed. Feeding levels during the interval from weaning to oestrus were 4 kg and 2.5 kg per sow per day. The number of sows in oestrus within 21 days of weaning was 69 (61 %). Within seven days of induction of oestrus on day 21, 41 sows were in oestrus (36 %). On day 21, 37 (65 %) of the better fed sows were in oestrus and 32 (53 %) of the poorer fed group. The interval from weaning to spontaneous oestrus was 9.1 and 8.2 days, respectively, and ovulation rate 15.2 and 14.8. Size of the sexual organs was not affected by feeding level. Rate of gain of the sows during the interval from weaning to oestrus was influenced by feeding level: +4.1 kg and −2.3 kg, respectively, for the sows in oestrus within 21 days of weaning.

Sows with induced oestrus shed significant more ova than sows in which oestrus was not induced (21.7 and 15.0 respectively). Loss of weight, loss of heart girth, and loss of back-fat thickness during previous lactation (absolute and relative) did not differ for sows with or without induction but was higher for sows with a spontaneous oestrus between 10 and 21 days after weaning than for sows with an oestrus within 10 days after weaning. Ovulation rate was not influenced by weight at weaning or at oestrus, weight loss during lactation, gain during the interval from weaning to oestrus or size of the preceding litter at birth.

Introduction

If nulliparous sows are given extra feed before oestrus ovulation rate increases (reviewed by den Hartog, 1980, and den Hartog & van Kempen, 1980). In primiparous and multiparous sows, however, the effect of flushing is less clear (reviewed by NRLO, 1979). Several studies have indicated that ovulation rate may be affected by body condition at mating or by weight change during the previous lactation (reviewed by Brooks & Cole, 1974). A high feeding level after weaning would have more effect in primiparous sows because of the greater (relative) weight loss during lactation than multiparous sows (Brooks et al., 1975). The effects of feeding level of the sow between weaning and conception and feed requirements need to be better defined (Brooks & Cole, 1974). Variations in nutrition from weaning until mating and during oestrus will influence ovulation rate. However NRLO (1979) concluded from an extensive review of the literature that there was hardly an effect of feeding level before and during oestrus on ovulation rate.

Weight of the sow at oestrus was correlated with weight of the uterus on day 28 of pregnancy and also with ovulation rate (Heap et al., 1967). The variability in ovulation rates as affected by high feeding level during the interval from weaning to oestrus makes more research necessary. Therefore that interval, ovulation rate and size of some sexual organs were examined in relation to feeding level. In our trial primiparous sows were used. They generally have more problems in coming into oestrus than multiparous sows (Mitic et al., 1967; Schlegel & Sklenar, 1971; van der Heijde et al., 1974; Kuiper & Sturm, 1975; Legault et al., 1975; Aumaitre et al., 1976; den Hartog, 1977).

Materials and methods

Animals

The trial included 121 Dutch Landrace sows raised in five consecutive batches. They had been reared as follows. They were suckled for 5 weeks, with a creep ration which was continued ad libitum till the age of ten weeks. On the basis of metabolic size, rations during rearing and first pregnancy were 93 g/kg$^{3/4}$ to a maximum of 2.5 kg per day. During their first lactation litters were standardized at birth to nine piglets. Sows were given 2.5 kg for the sow and 0.25 kg for each piglet (from day 21 till day 35). During rearing and pregnancy, sows were housed in groups of four and after weaning in groups of three. More detail will be given by van der Steen (1982). If sows did not show oestrus within 21 days of weaning, oestrus was induced with 400 I.U. of Pregnant Mare Serum and 200 I.U. of Human Chorion Gonadotrophin (PG 600® (Intervet B.V., Boxmeer, Netherlands)) intramuscularly. All animals were slaughtered within 7 days after oestrus or oestrus induction.

Feeding level

After five weeks of lactation, the primiparous sows were assigned to one of two feeding levels: 4 and 2.5 kg of feed per day. To allow equal opportunity to feed at the low level, the three sows in a pen were fed once a day. During the whole trial, the feed was formulated in the same way (Table 1). Once a week, feed was sampled and bulked for analysis after the batch. Kjeldahl nitrogen was expressed as crude protein (6.25 times the fraction of N). Ash was estimated by ashing at 550 °C, crude fat by ether extraction, crude fibre by the method of NEN-3326 (1966). Gross energy was determined by bomb calorimetry (Table 2).

Table 1. Formulation of the feed.

Ingredients	Mass fraction (%)
Maize	12
Barley	18
Soya bean oilmeal (with 44-47 % crude protein)	15
Pollards	15
Tapioca pellets	13
Maize gluten feed	5
Lucerne meal	8
Citrus pulp	5.5
Animal feed	1.1
Molasses	5
Minerals/vitamins premix*	2
Calcium hydrogen phospate	0.4

* Guaranteed contents: Ca 253 g/kg, P 75 g/kg, Na 60 g/kg, Cu 500 mg/kg, Fe 4000 mg/kg, Zn 2000 mg/kg, Mn 1200 mg/kg, Co 12.5 mg/kg, J 20 mg/kg, Se 2.5 mg/kg, 3500 μg retinol equivalent/kg, 1750 μg Cholecalciferol equivalent/kg, riboflavin 175 mg/kg, 900 mg nicotinamide equivalent/kg, pantothenic acid 350 mg/kg, choline 12500 mg/kg, vitamin B-12 0.75 mg/kg, 235 mg α-tocopherol equivalent/kg, dl methionine 10 g/kg.

Table 2. Composition of the feed as analysed and calculated. Values are mass fractions in fresh matter (%).

	By analysis (mean ± standard deviation)	By calculation (CVB 1979)
Dry matter	87.64 ± 0.67	87.45
Ash	6.59 ± 0.43	7.22
Crude protein	15.11 ± 0.64	15.87
Crude fat	3.26 ± 0.56	3.40
Crude fibre	7.09 ± 0.46	6.74
Gross energy content (MJ/kg)	15.86 ± 1.66	
Net energy content (MJ/kg) by Rostock equation		8.57

Traits

The recorded, measured and calculated traits are given in Table 3. Back-fat thickness was measured ultrasonically.

Statistical method

Data were first tested by the following model:

$$Y_{ijklm} = \mu + A_i + B_j + C_k + (AB)_{ij} + (AC)_{ik} + (BC)_{jk} + q_l X_l + e_{ijklm} \quad (1)$$

in which:
Y_{ijklm} = dependent variable
μ = mean
A_i = feeding level (i = 1, 2)
B_j = oestrus induction (j = 1, 2)

Table 3. The traits which were recorded, measured or calculated with their abbreviation.

Trait	Abbreviation
Number of pigs born	(LS)
Weight at the day before farrowing	(W_{F1})
Weight at the day after farrowing	(W_{F2})
Back-fat thickness at farrowing	(B_{T1})
Heart girth at farrowing	(H_{G1})
Weight at weaning	(W_W)
Back-fat thickness at weaning	(B_{T2})
Heart girth at weaning	(H_{G2})
Weight at oestrus	(W_o)
Interval weaning-oestrus	(I_{wo})
Weight loss during farrowing	($W_{F1}-W_{F2}$)
Weight loss during lactation	($W_{F2}-W_w$)
Loss of back-fat thickness during lactation	($B_{T1}-B_{T2}$)
Loss of heart girth during lactation	($H_{G1}-H_{G2}$)
Rate of gain in the interval weaning-oestrus	(W_o-W_w)
Weight of uterus and ovaries	(W_{uov})
Weight of the ovaries, left and right	(W_{ov})
Weight of the uterus horns, left and right	(W_u)
Length of the uterus horns, left and right	(L_u)
Number of corpora lutea, left and right	(CL)

C_k = batch (k = 1 . . . 5)
$(AB)_{ij}$ = two-way interaction
$(AC)_{ik}$ = two-way interaction
$(BC)_{jk}$ = two-way interaction
$q_l X_l$ = effect of one covariable
e_{ijklm} = error

The covariables tested by the model were LS, (W_{F2} - W_w), B_{T1} -B_{T2}, W_w, W_o or (W_w - W_o) (Table 3) with the assessment covariables and factors concurrently. After that analysis the following model was used:

$$Y_{ijklm} = \mu + A_i + B_j + C_k + (AB)_{ij} + b_l X_l + e_{ijklm} \qquad (2)$$

with A_i, B_j and $(AB)_{ij}$ always part of the model, and C_k and one or more covariable(s) ($q_l X_l$) part of the model when their effects were significant. To calculate the means of the effects mentioned in Model 2, the computer program LSML76 (Harvey, 1977) was used.

Differences in standard deviation were tested by the F test (ISO-3534, 1977). Differences in CL and IWO for the experimental groups were tested by the Kruskall Wallis test (Siegel, 1956), because of the heterogeneity of variances and the skew distribution. If one of the two variables was used in calculation of a correlation, the Spearman (ranking) correlation coefficient was calculated; otherwise Pearson correlation coefficients were determined.

Results

Data from 112 sows were used for analysis because 8 sows had been rejected for various reasons and 1 sow is not slaughtered. The analysis with Model 1 showed that batch had significant effect on weight of the ovaries and length of uterus.

Feeding level

Sows on the high feeding level gained more weight in the interval weaning-oestrus than sows on the low feeding level did (Table 4). The number of corpora lutea increased with oestrus induction. The proportion of sows in oestrus on the high and low feeding level at various times after weaning are given in Fig. 1. More sows on the high feeding level (65 %) than on the low level (53 %) come into heat by day 21 after weaning ($\chi^2 = 2.10$; $P = 0.15$). On day 10 after weaning, the proportion of sows in oestrus was equal for the two groups. Correlation coefficients of liveweight and reproductive traits were compared within feeding level between sows with a spontaneous oestrus and sows with an induced oestrus (Table 5). The correlations between weight of the sow at oestrus and size of the sexual organs were negative for the sows with spontaneous oestrus on the high feeding level and sows with an induced oestrus on the poorer reation. For the

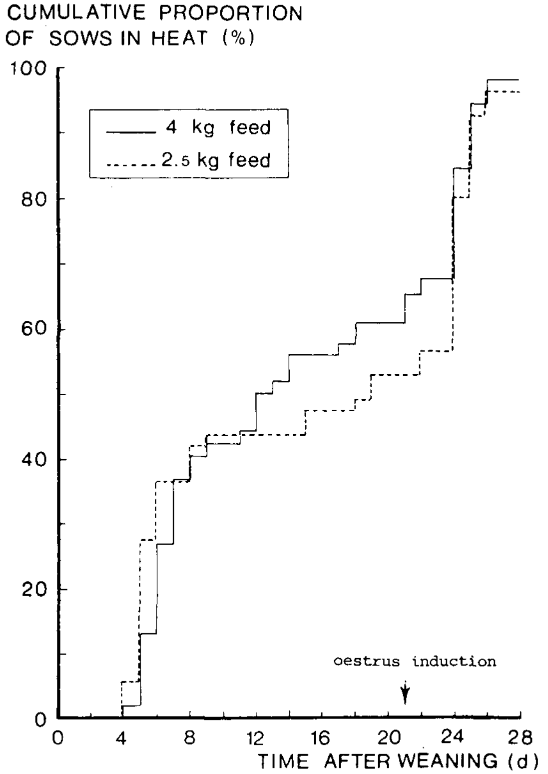

Fig. 1. The proportion of sows in heat on the two feeding levels at various times after weaning.

Table 4. Some data of induced and not induced primiparous sows with a different feeding level (H and L) (mean ± standard deviation).

	Non-induced sows		Induced sows		Standard deviation within treatment	Effect of[1]			Used covariables and batch (C_k) as variable
	H	L	H	L		feeding level (H-L)	oestrus induction (yes = no)	inter-action	
Number of sows	37	32	17	26					
I_{wo} (d)[2]	9.1 ± 4.9	8.2 ± 4.8	24.4 ± 0.9	24.3 ± 1.0			**		
$(W_o - W_w)$ (kg)	4.1	−2.3	13.0	3.5	7.6	**	**		$(W_{F2} - W_w)$, W_w
W_{uov} (g)	551	567	599	598	135				LS
W_u (g)	511	532	562	547	135				LS
W_{ov} (g)	10.5	11.2	12.5	10.8	4.3				$C_k.LS$
L_u (cm)	254	255	284	300	58		**		$C_k.LS$
CL[2]	15.2 ± 3.4	14.8 ± 2.9	21.3 ± 6.7	21.7 ± 8.5			**		$(W_{F2} - W_w)$

1 ** $P < 0.01$.

2 Variances within subgroups differ significantly so differences between treatments are tested by non-parametric test.

Table 5. Coefficients of correlation (a = Pearson; b = Spearman) between weight of the sows and reproductive performance within feeding level in 69 sows with spontaneous oestrus and 43 sows with induced oestrus.

Correlation of	Spontaneous oestrus		Induced oestrus	
	H	L	H	L
LS and W_{F2} (a)	– 0.58 ***	– 0.03	0.03	0.35 *
W_o and W_{uov} (a)	– 0.38 **	0.21	0.17	– 0.27
W_o and W_u (a)	– 0.35 *	0.18	0.18	– 0.30 *
W_o and W_{ov} (a)	– 0.26 *	0.07	0.09	– 0.30 *
W_o and L_u (a)	– 0.31 *	0.11	0.13	– 0.28 *
W_o and CL (b)	0.06	– 0.06	– 0.08	– 0.18
W_w and I_{wo}(b)	– 0.33 *	– 0.25 *	0.13	– 0.02
W_w and $(W_o - W_w)$ (a)	– 0.41 **	– 0.36 *	– 0.38 *	– 0.28 *
CL and W_u (b)	0.13	0.25 *	0.22	0.42 **
CL and L_u (b)	0.20	0.26 *	0.07	0.38 *
CL and W_{ov} (b)	0.36 *	0.72 ***	0.53 **	0.63 **

* $0.01 < P \leqslant 0.10$; ** $0.001 < P \leqslant 0.01$; *** $P \leqslant 0.001$.

Table 6. Characteristics of weight change for sows with spontaneous and induced oestrus (mean ± standard deviation).

	Sows with spontaneous oestrus 21 days after weaning	Sows with induced oestrus or no oestrus at all	Significance ($P \leqslant 0.05$)
Number of sows	71	42	
Weight loss during farrowing (kg) $(W_{F1} - W_{F2})$	18.2 ± 6.2	18.9 ± 5.4	n.s.
Loss of heart girth during lactation (cm) $(H_{G1} - H_{G2})$	12.1 ± 3.2	12.6 ± 3.9	n.s.
Loss of back-fat thickness during lactation (mm)$(B_{T1} - B_{T2})$	6.7 ± 2.2	6.8 ± 2.1	n.s.
Weight loss during lactation (kg) $(W_{F2} - W_W)$	34.0 ± 9.5	35.2 ± 9.3	n.s.
Weight at weaning (kg) (W_W)	147.5 ± 13.7	146.7 ± 10.9	n.s.
Back-fat thickness at weaning (mm) (B_{T2})	14.8 ± 4.1	14.1 ± 4.0	n.s.
Heart girth at weaning (cm) (H_{G2})	112.0 ± 5.0	110.9 ± 4.3	n.s.
Relative loss of weigth during farrowing (%) $(W_{F1} - W_{F2})/W_{F1}$	9.1 ± 3.0	9.4 ± 2.4	n.s.
Relative loss of heart girth during lactation (%) $(H_{G1} - H_{G2})/H_{G1}$	9.7 ± 2.5	10.2 ± 3.0	n.s.
Relative loss of back-fat thickness during lactation (%) $(B_{T1} - B_{T2})/B_{T1}$	31.7 ± 10.4	32.9 ± 10.7	n.s.
Relative loss of weight during lactation (%) $(W_{F2} - W_W)/W_{F2}$	18.7 ± 5.0	19.2 ± 4.5	n.s.

other groups, there was no significant correlation. The ovulation rate was always positively correlated with the size of the sexual organs, but there was no correlation between weight of the sow at oestrus and ovulation rate. Data on body measurements of the sows with spontaneous and induced oestrus are given in Table 6 where there were no significant differences in relative and absolute characteristics of weight change for the two groups. Sows with a spontaneous oestrus between day 10 and day 21 after weaning had lost more weight, more back-fat, and more heart girth during lactation and were in poorer condition at weaning than sows with an oestrus within 10 days after weaning.

Season

Effect of batch on length of the uterus horns ($P < 0.001$) and weight of the ovaries ($P < 0.01$) was significant (Table 3). The sexual organs tend to be heavier and longer in winter than in summer and intermediate in spring and autumn. Fahmy et al. (1979) found that season of farrowing had significant effect on length of the interval from weaning to oestrus, with the shortest interval in autumn and the longest in spring and summer. There was no effect of batch on the interval from weaning to oestrus nor on the proportion of sows in oestrus within 21 days after weaning (Table 7).

Size of sexual organs

The weight of the uterus or ovaries was not affected by the weight of the sow at weaning or at oestrus, by the weight loss during lactation, or the rate of gain in the interval from weaning to oestrus (standardized regression coefficient for W_{uov} was 0.25 for W_u 0.22 and for W_{ov} 0.27). Sows with induced oestrus had longer uterus horns ($P < 0.01$). The length of the uterus horns was positively related to litter size and weight loss of the sow during the previous lactation ($P < 0.05$).

Rate of gain

Rate of gain from weaning to oestrus was affected by feeding level ($P < 0.001$) and by the need for induction ($P < 0.001$). The interval from weaning to oestrus was on average 24 days with induced oestrus and 8-9 days with natural oestrus ($P < 0.001$).

Sows with a 'low weight' at weaning and sows with a 'great weight loss' during

Table 7. Proportion of sows in oestrus within 21 days of weaning and interval form weaning to oestrus for those sows of each of the five batches (mean ± standard deviation).

Time of trial	Number of sows	Proportion of sows in oestrus (%)	Interval from weaning to oestrus (d)
June and July 1979	21	42.8	8.8 ± 5.0
September and October 1979	24	66.7	9.1 ± 5.7
December 1979	24	62.5	9.0 ± 4.0
March 1980	30	63.3	7.5 ± 4.2
June 1980	14	71.4	9.6 ± 6.2
Total/Mean	113	61.1	8.8 ± 4.9

lactation gained more during the interval than sows with a higher weight or with a smaller weight loss ($P < 0.001$).

Interval from weaning to oestrus

Influences on the interval from weaning to oestrus were tested for sows with a spontaneous oestrus. Feeding level and preceding litter size did not influence the interval. It was positively related to weight loss during lactation ($P < 0.001$) and negatively with weight of the sow at weaning ($P < 0.02$).

Discussion

Effect of feeding level on oestrus

Sows should reach oestrus soon after weaning. The interval from weaning to oestrus was not affected by feeding level after weaning. This agrees with the results of the literature review by NRLO (1979). The proportion of sows in oestrus increases faster between day 9 and day 21 after weaning for the better fed group than for the poorer fed group. In trials of Brooks & Cole (1972) and Fahmy & Dufour (1976), the number of sows in oestrus after weaning was increased with a high feeding level, but Etienne et al. (1976) found no difference. Dijck (1972), however, found a smaller varation in the interval from weaning to oestrus when feeding level was high. It is not clear from literature whether sows that do not come into oestrus are not stimulated enough for follicular growth or whether their ovaries do not react to the stimulus.

Effect of feeding level on size of sexual organs

Feeding level did not have a significant effect on the weight of the ovaries. This agrees with the results of Etienne & Legault (1974) and Fahmy & Dufour (1976) in flushed gilts and sows over a longer or shorter time. Feeding level did not influence the length of the uterus and the weight of uterus and ovaries together. Heap et al. (1967) found no relation between feeding level during early pregnancy and length or weight of the sexual organs 28 days after mating. Weight of the empty uterus (y) 28 days after mating increased with weight of the sow at mating (x): $1000\ y = a + 0.93x$ ($P < 0.05$), where $a = 304.6$ kg. There was no significant relation between weight of the sow and length of the uterus. For the sows with a spontaneous oestrus on the better ration and sows with an induced oestrus on the poorer ration the relation between weight at oestrus and size of the sexual organs was negative (Table 5). The correlation of litter size at birth and weight of the sow after farrowing was negative for the first group and positive for the last. So the relation between litter size and weight after farrowing cannot explain the relation between weight at oestrus and size of the sexual organs. In the poorer fed sows with a spontaneous oestrus and the better fed sows with an induced oestrus there was no clear relation between weight of the sow at oestrus and size of the sexual organs.

Effect of feeding level on ovulation rate and rate of gain of the sow
On the basis of the literature, NRLO (1979) found no clear effect of high feeding level after weaning on the ovulation rate. Dijck (1974) also found that flushing in primiparous sows mated at first oestrus had no effect. According to van der Heijde & Lievens (1977), there was only an effect of flushing on the ovulation rate in sows after a period of undernutrition. Some authors, however, have found a significant positive linear relation of ovulation rate with: weight at weaning (Moody & Speer, 1971), weight at oestrus (Heap et al., 1967) and rate of gain during the interval from weaning to oestrus (Hardy & Lodge, 1969). Hardy & Lodge (1969) also found a significant inverse relation of weight loss during the previous lactation period with ovulation rate. King & Young (1957) found no significant relation between weight of the sow and ovulation rate.

Feeding level, weight at weaning and weight loss during lactation had an effect on the rate of gain during the interval from weaning to oestrus. If a sow, during the first month after weaning, does not gain 140-150 g/d, oestrus will be difficult to reach (Maclean, 1969; reviewed by Rasbech, 1969).

Induction of oestrus
Whether sows show spontaneous oestrus by 21 days after weaning is not only related to condition of the sow at weaning as expressed by weight of the sow, backfat thickness or heart girth. For sows with a spontaneous oestrus, feeding level between weaning and mating stimulates the onset of oestrus for sows with a poor condition. With induced oestrus, the greater length of the uterus could result either from the longer terval or from induction. Within the sows with spontaneous oestrus there was no relation between length of the interval weaning to oestrus and length of the uterus. This suggests that the difference is due to the induction.

The positive relation of litter size at birth with size of the sexual organs at oestrus would be explained by the increased development of the uterus during last pregnancy in spite of involution, which would be complete four weeks after farrowing. Size of preceding litter at birth was not related to the interval from weaning to oestrus, as was found by Legault et al. (1975).

High feeding level necessary before mating
A high feeding level in normal sows after weaning must be used, not to increase ovulation rate but to improve the condition of the sow and to advance oestrus. The number of sows in oestrus within 21 days of weaning was greater for sows on a high feeding level. Improved condition must be obtained before mating since a high feeding level early in pregnancy is unfavourable for the embryonic survival (reviewed by den Hartog & van Kempen, 1980). The increased number of sows in oestrus with better feeding could result from an extra stimulation of the hypophyseal-hypothalamic system or of the ovaries by increased glucose concentration of blood. Flushing of gilts may increase glucose in blood (Zimmerman et al., 1958; Kirkpatrick et al., 1967). This may be beneficial for oestrus because sows need more energy during oestrus (Verstegen, 1980).

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